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(54) Transmitting signal from sensor to receiver by inductive coupling

(57) A signal is transmitted from a sensor to a remote receiver monitoring that sensor, by an electromagnetic link between transmitter and receiver. Preferably, the electromagnetic link is established between a transmitter coil or loop aerial through which a frequency and/or amplitude modulated current flows and a receiver having a co-operating coil or loop aerial in which a current is induced by the transmitted signal. This can be used in a security system e.g. for intruders or fire.

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TITLE: METHOD AND APPARATUS FOR TRANSMITTING SIGNALS

The present invention relates to a method and apparatus for transmitting signals, notably by means of an electromagnetic inductive link, generated in response to the activation of a sensor in a security system.

BACKGROUND TO THE INVENTION:

Many forms of security system are known in which a sensor detects some change in an observed function, for example the change in infra-red radiation due to the presence of an intruder in a room, vibration or foot pressure as the intruder walks across a floor, movement of a door or window, the presence of smoke in the case of a fire and so on. The sensor can be used to activate an alarm, for example a visual or audible alarm, or to activate some other activity, for example to control the operation of a water sprinkler system in case of a fire or the addition of a reagent or to initiate a cooling cycle in the case of a chemical plant where the sensor monitors the temperature or level of a reaction mixture in a vessel.

For convenience, the term "sensor" will be used hereinafter to denote in general terms any device which monitors an environment to detect a change in an observed characteristic or the occurrence of some function within that environment, and which is adapted to emit some signal to denote the occurrence of that change or function. Also, the term security system will be used hereinafter to denote in general any system which uses the actuation of a sensor to initiate some other function, although it will be appreciated that the

other function may not be an alarm but may be some control system where the sensor monitors the condition of an environment as described above.

The signal from the sensor may have to be transmitted some distance to a receiver, which may also monitor and control the functioning of a number of other sensors. The signal can be transmitted by a number of methods, for example by transmitting the signal through wires connecting the sensor (or a signal transmitter associated therewith) to the alarm or other receiver in the system; or by transmitting the signal through the air or other medium between the sensor and the receiver as an infra-red, ultra-sonic or radio signal or a pressure pulse in an hydraulic or pneumatic line.

However, such systems can be cumbersome and may suffer from interference from the environment which can falsely trigger the alarm or receiver. Thus, wire connection requires costs and labour to install and may be intrusive. Furthermore, wires may be readily accessible to an intruder who can disconnect a sensor from the system and may thus disable the security or operation of the system at that point. Where the signal is transmitted through the air, as in the case of ultra-sonic or radio signals, problems due to cutting of wire conductors are reduced, but the transmitted signals are susceptible to interference from the environment and their propagation may be uncertain due to reflection and/or absorbtion by materials in the path of the transmission.

Thus, radio transmissions suffer from unpredictable effects caused by reflection from and/or absorbtion by the structural materials of buildings within which the signals are

transmitted. As a result, reception may be uncertain and it is usually necessary to use high radiated power signals to ensure interference-free reception under all conditions. Such high radiation power levels can cause interference with other systems outside the required range of transmission and are often limited by legislation to minimise such interference.

Ultrasonic and infra-red signals are limited to line-of-sight transmissions and therefore their use is restricted to sites where such lines-of-sight exist.

We have now devised an improved method for transmitting the signals between a sensor in a security system and the receiver monitoring the output from that sensor, which reduces the above problems with conventional security systems.

SUMMARY OF THE INVENTION:

Accordingly, the present invention provides a method for transmitting a signal from a sensor to a receiver monitoring that sensor, which method is characterised in that the signal is transmitted by an electromagnetic link between the transmitter and the receiver.

The term "electromagnetic link" is used herein to denote a system where a magnetic field is produced by passing a current through a first conductor and this magnetic field induces an EMF in an adjacent but separate second conductor, either by changes in the current flowing in the first conductor and/or by relative movement between the second conductor and the magnetic field. Unlike a radio signal, the magnetic field produced by this means exists only by virtue of the current

flowing in the first conductor and is not radiated as energy. With the exception of a minute amount of absorption in the second conductor or receiver and in any dissipative medium lying within the magnetic field, substantially all of the energy stored in the magnetic field is returned to the first conductor.

The intensity of the field can be large close to the first conductor, but falls off in proportion to the inverse of the cube of the distance from the first conductor. As a result, at a relatively short distance the field becomes virtually undetectable. This fact can be used to ensure that the electromagnetic link can be designed to suit a particular application so as to avoid interference with other sustems in excess of the designed range for that application. Furthermore, dissipation and reflection of the electromagnetic link in most non-ferromagnetic materials is minimal and the link is thus largely unaffected by the structure of a building within which it is used.

The electromagnetic link can be generated by a wide range of inductance generators by passing a current through a conductor and detecting the magnetic field associated with that current by a suitable receiver. The conductor can be a simple straight wire, in which case the magnetic field will have a generally doughnut shape axially symmetrical about the longitudinal axis of the conductor. However, it will usually be preferred to form the first conductor as a loop or coil of one or more turns of wire about an axial axis. If desired, the turns can be about an air core. However, it may be preferred to wind the coil about a suitable core to enhance the strength and directionality of the magnetic field.

Typically, the core is a ferromagnetic rod, eg. of mild steel or ferrite, axially located within the coil and extending axially beyond the turns of the coil. Alternatively or in addition, the direction of the magnetic field can be further shaped by placing metal sleeves or plates around or adjacent the coil so that they reflect or shape the field to the desired form. The optimum shaping can readily be determined by simple trial and error tests. For convenience, the invention will be described hereinafter in terms of a transmitter wherein the aerial is in the form of a simple coil having a ferrite rod core. The term "magnetic signal" will for convenience be used hereinafter to denote the electromagnetic inductance link established between the transmitter and the receiver.

The transmitter can transmit any suitable form of magnetic signal upon being actuated by the sensor it serves. Preferably, the sensor operates by generating an electrical signal which can be fed directly to the transmitter to actuate it. However, the invention can be applied to other forms of sensor, in which case it may be necessary to provide some intermediate circuitry to convert the initial signal from the sensor, for example to convert a mechanical, optical or thermal signal into an electrical signal and/or to amplify or pre-treat that signal in some way to make it suitable for interfacing with the selected transmitter. Such conversion and interfacing circuitry can be of conventional design and operation. For convenience, the invention will be described hereinafter in terms of a sensor which emits a signal which can be fed directly to the transmitter.

The sensor can emit a signal continuously to indicate an active and steady state or can emit a signal only when it is triggered. For convenience, the invention will be described hereinafter in terms of a sensor which emits a signal when it is activated.

The signal from the sensor is fed to the associated transmitter, which is preferably constructed as an integral part of the sensor unit, to generate a suitable signal to be transmitted to a remote receiver. The transmitter can transmit a continuous magnetic signal which is interrupted or changed when the sensor is activated. Alternatively, the transmitter can remain quiescent until activated by a signal from the sensor and/or from the receiver as described below. Thus, the transmitter can transmit a continuous constant magnetic signal as when a DC current is applied to the aerial coil, and then transmit a different signal when activated by the sensor so that the receiver will detect the change in the field when the different signal is transmitted. For convenience, the invention will be described hereinafter in terms of a transmitter which remains quiescent until activated by a signal from the sensor.

As indicated above, the transmitter can transmit a continous and constant signal, as when a steady DC current signal is applied to the aerial coil and actuation of the sensor causes a change in that signal, for example to switch of the signal or to vary the amplitude of the signal. However, this may require a complex receiver having a moving aerial to receive and detect such a steady magnetic signal and the transmission of such a continuous magnetic signal may impose current drain

requirements on the battery powering the transmitter which are unacceptable.

It is therefore preferred that the transmitter transmit a varying magnetic signal which can be simply detected by a static coil aerial in its path. The variation can be of the signal on/off type, as when the magnetic signal is pulsed by means of an oscillator circuit driving the current to the transmitter aerial coil. Alternatively, the variation can be by means of changes in the amplitude and/or frequency of the magnetic signal. Thus, the transmitter can incorporate a circuit for generating a sinusoidal wave form current which is used to provide a carrier wave magnetic signal from the aerial, which wave is modulated by applying changes to its amplitude and/or frequency. The modification of the carrier magnetic signal from the transmitter can be achieved by a wide range of conventional methods and circuits. The modification of the transmitted signal could also be achieved by transmitting two magnetic signals out of phase with one another and detecting the beat frequency of the resultant signal at the receiver. For convenience, the invention will be described hereinafter in terms of a transmitter incorporating an oscillator circuit and which transmits a pulsed magnetic signal to the receiver.

The magnetic signal can have any desired amplitude and frequency, having regard to the environment in which the sensor and transmitter are to be used. In general, the lower the frequency of the transmitted magnetic signal and the higher the current passed through the aerial coil, the greater the range over which the magnetic signal can be transmitted. Thus, it will usually be preferred to operate the transmitter

at signal frequencies in the low or very low frequency bands, typically 3kHz to 300kHz. In practice, local legislation may limit the frequency ranges which may be used. For example in the United Kingdom, the permitted frequency ranges lie within the band range 120 to 180 kHz.

The magnetic signal from the transmitter can carry other information, in addition to the status of the sensor it serves. Thus, the signal can incorporate a component which identifies the signal as coming from a given transmitter, for example by incorporating an address frequency or coding in the pulses, which can be used to identify to the receiver which sensor is activated and/or to validate the signal so as to discriminate it from an extraneous signal or a counterfiet signal from an intruder. The coding, validation or other function of the modulation of the transmitted magnetic signal can be achieved in a number of ways using conventional scrambling or signal processing techniques.

If desired, the transmitter can incorporate timer or other control means whereby the transmitter will transmit a signal, which is preferably a magnetic signal, at given intervals to the receiver to establish that the transmitter and sensor are still active and have not been disabled for any reason. This control means, for example a timer counter and associated ROM, can be of any suitable form and may incorporate intelligence so that the receiver can activate the transmitter and interrogate it so as yet further to enhance the security and reliability of the system.

As indicated above, it is preferred that the transmitter be battery powered so that the sensor/transmitter unit can be

formed as a self-contained unit which can be located wherever desired. However, on some systems, it may be preferred to drive the transmitter by mains electricity, notably where the signal from the transmitter is to travel considerable distances. Alternatively, the signal may be passed to a relay receiver/transmitter, which can serve a number of transmitters, for onward transmission to a further remote receiver, for example via the telephone lines.

The magnetic signal from the transmitter is detected by any suitable receiver which will usually incorporate one or more aerials of a type similar to that present in the transmitter. Thus, it will usually be preferred that the receiver incorporate at least one coil aerial oriented transverse to the expected direction of the lines of flux in the transmitted magnetic signal. Where a number of transmitters are being served by a single receiver, it may be desired to incorporate two or three aerial coils aligned mutually perpendicular to one another to enhance the reception of the transmitted magnetic signals, for example where the security system of the invention is used in a multi-storey building with sensors on a number of floors linked in to a central receiver. The receiver will also incorporate one or more suitable demodulating circuits corresponding to the modulating circuits used in the transmitter(s); and may incorporate suitable descrambling circuits where the transmitted magnetic signals have been scrambled, for example by the use of the beat frequency of a pair of transmitted signals. As indicated above, the receiver may incorporate other functions to enhance the security of the system, for example to detect validation codings or portions of the transmitted signals or to transmit signals to the transmitters to generate a response signal from

the transmitter to indicte the continued functioning of that transmitter.

The circuitry used in the transmitter and receiver can be of conventional design and construction having regard to the type of signal to be transmitted and received and the requirement that the transmitted signal be an inductance link by virtue of the use of a magnetic field generation and reception.

Accordingly, the present invention also provides a security system which comprises:

a. one or more sensors having operatively associated therewith a transmitter comprising signal generation means and an inductive aerial signal emission means adapted to transmit an electromagnetic inductive signal, and preferably also signal modulation means for modulating the transmitted signal whereby the signal carries verification, coding and/or address information relating to that transmitter; and

b. a remote receiver means adapted to receive and interpret the signals from a plurality of the said transmitters and to monitor the status of the sensors served by those transmitters.

The invention provides a means for linking a sensor to a receiver monitoring the status of that sensor which can be used in a wide range of locations where conventional security systems would not be suitable. The aerials required for the electomagnetic inductance link transmitter and receiver are in general more compact than those required for radio signal transmissions, which enables a smaller and cheaper assembly to be used. Magnetic field signals will pass through most materials which thus gives the user greater freedom in the

location of the sensor/transmitter units than might be possible with radio transmitters or with line-of-sight transmission devices such as infra-red transmitters. The power of the magnetic signal transmitted can be selected according to the range required and the signal can be made directional, even in the close vicinity of the transmitter, thus reducing the risk that the signal will interfere with other systems.

The method and apparatus of the invention find wide spread use wherever it is desired to monitor an environment and to report the status of that environment to a remote receiver. Thus, the invention finds use in a wide range of forms of security systems and also in environments where there are fire risks, since the transmitter can be operated at low voltages with little risk of sparks or the like which might occur with the high voltages required for radio transmissions. Thus, the invention can be used to transmit the signal from a sensor monitoring the conditions within a reaction vessel so as to activate the addition of a coolant or a reagent in response to the signal from the sensor, notably where the reaction environment contains solvent vapours or other fire hazards.

CLAIMS:

1. A method for transmitting a signal from a sensor to a remote receiver monitoring that sensor, which method is characterised in that the signal is transmitted by an electromagnetic link as hereinbefore defined between the transmitter and the receiver.

2. A method as claimed in claim 1, wherein the signal is transmitted from an aerial comprising a loop or coil aerial through which a varying current is flowing.

3. A method as claimed in either of claims 1 or 2, wherein the signal is transmitted as a wave form carrier signal which is pulse and/or frequency or amplitude modulated.

4. A method as claimed in any one of the preceding claims wherein the transmitted signal has a frequency in the range 120 to 180 kHz.

5. A method as claimed in any one of the preceding claims wherein the signal is transmitted from an aerial having signal shaping means.

6. A method as claimed in claim 5, wherein the aerial is a coil aerial having a ferromagnetic core.

7. A method as claimed in any one of the preceding claims, wherein the transmitted signal is received by a receiver incorporating one or more coil or loop aerials, at least one

of which is orientated transversely to the direction of the lines of flux in the transmitted signal.

8. A method as claimed in claim 1 substantially as hereinbefore described.

9. Apparatus for use in a method as claimed in claim 1, comprising a sensor adapted to emit an electrical signal in resonse to a change in the conditions of or an occurence within an environment monitored by that sensor; a signal transmitter comprising a coil or loop aerial and having means for generating a current to be passed through the aerial in response to the signal from the sensor so as to generate an electromagnetic signal from the aerial; a receiver comprising a coil or loop aerial adapted to form an electromagnetic link with the aerial in the transmitter and to have a current induced therein by the signal emitted from the transmitter aerial; and means responsive to the current induced in the receiver aerial.

12. A security system which comprises:

a. one or more sensors having operatively associated therewith a transmitter comprising signal generation means and an inductive aerial signal emission means adapted to transmit an electromagnetic inductive signal; and

b. a remote receiver means adapted to receive the signals from a plurality of the said transmitters and to monitor the status of the sensors served by those transmitters.

13. Apparatus as claimed in claim 12, wherein the transmitter is provided with signal modulation means for modulating the transmitted signal whereby the signal carries verification,

coding and/or address information relating to that transmitter.

14. Apparatus as claimed in either of claims 12 or 13, wherein the transmitter comprises a coil or loop aerial and the transmitted signal is generated by means adapted to pass a frequency and/or amplitude modulated current through the coil; and the receiver comprises a coil or loop aerial adapted to receive the transmitted signal and to have a current generated therein by the transmitted signal whereby an electromagnetic link is formed between the transmitter and the receiver.

15. Apparatus according to claim 12 substantially as hereinbefore described.

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